

LOW TEMPERATURE THERMAL DESORPTION (LTTD)

Foster Wheeler Environmental Corp.

LTTD - OVERVIEW

- ▶ **What is Low Temperature Thermal Desorption?**
- ▶ **Applicability of LTTD Systems**
- ▶ **Overview of Various Types of LTTDs**
- ▶ **Design and Performance Characteristics**
- ▶ **Cost Information**
- ▶ **Example: Naval Station Mayport**
- ▶ **Example: American Thermostat**

WHAT IS LOW TEMPERATURE THERMAL DESORPTION?

LTTD DEFINITION

KEY POINTS

- ▶ **Physical separation process**
- ▶ **Soils heated to 300° to 600°F**
- ▶ **Soil essentially retains its physical properties**
- ▶ **Volatize moisture and organics**
- ▶ **Not designed for inorganics removal/treatment**
- ▶ **Off-gas treated by condensation, collection, or combustion**
- ▶ **Extension of LTTD to treat higher boiling point organics by heating soils above 600°F, typically to 1,000°F (High Temperature Thermal Desorption)**

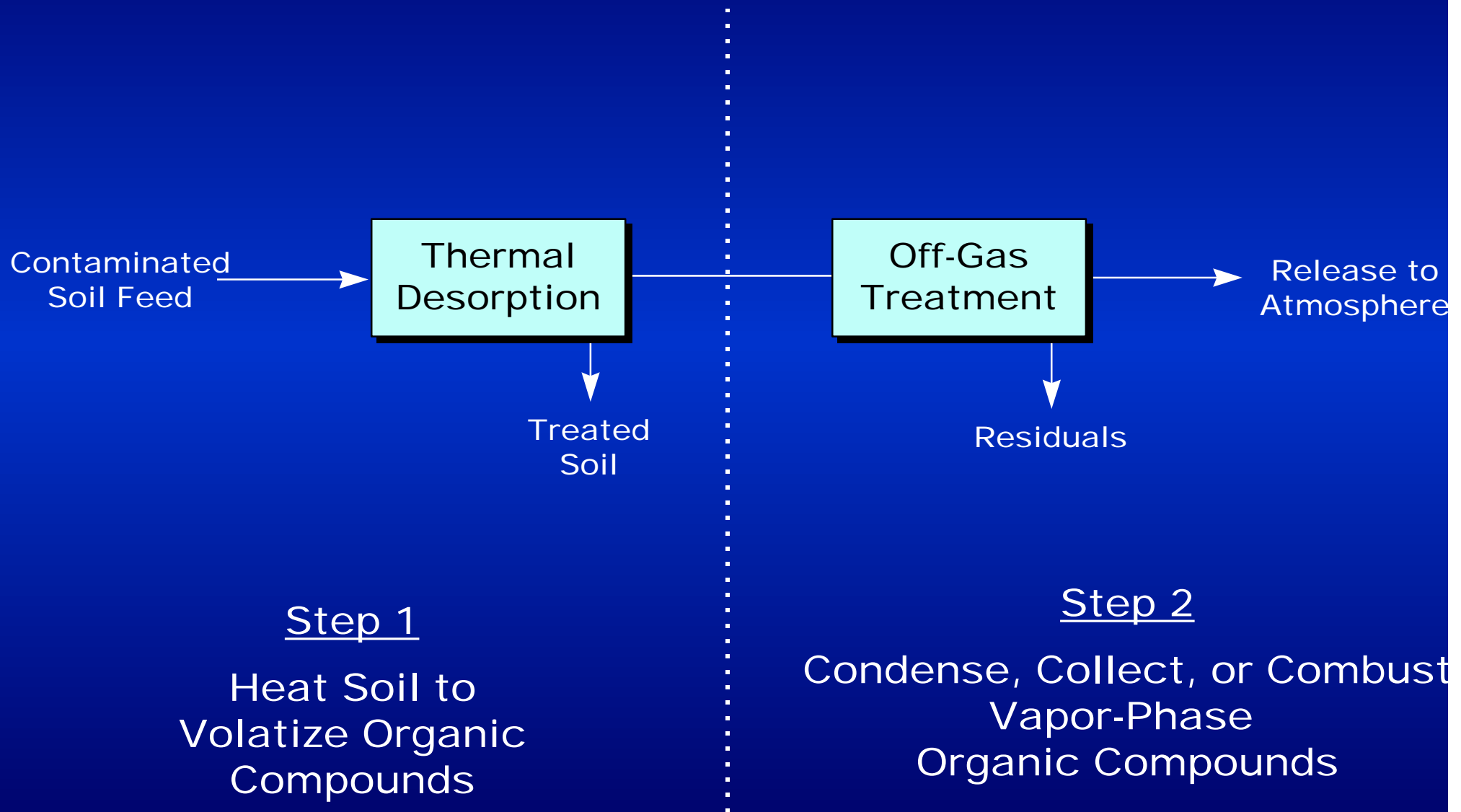
LTTD DEFINITION

KEY POINTS

(CONTINUED)

- ▶ **This definition is controversial - evolving**
- ▶ **Off-gas treatment by combustion may be viewed as incineration**
- ▶ **Check with local state and federal regulators early in the project**
- ▶ **LTTD can be referred to by other names or acronyms such as Low Temperature Enhanced Volatilization or LTEV**
- ▶ **Has been recognized as a remedial technology by EPA for more than 10 years**

GENERIC LTTD PROCESS



APPLICABILITY OF LTTD SYSTEMS

APPLICABILITY OF LTTD SYSTEMS

- ▶ **Petroleum, VOC, SVOC, pesticides and other organic contaminants with boiling points generally up to 600°F**
- ▶ **For organic contaminants with boiling points above 600°F (such as PCBs), consider High Temperature Thermal Desorption**
- ▶ **Thermal desorption is not applicable for treatment of inorganic wastes, such as metals**
- ▶ **Various residuals are generated - such as particulate, spent carbon, wastewater, filters, combustion gas - which need to be disposed of or managed**

TYPICAL LTTD RESIDUALS FOR MANAGEMENT AND/OR DISPOSAL

- ▶ **Clean offgas**
- ▶ **Spent carbon**
- ▶ **Concentrated contaminants**
- ▶ **Condensed water**
- ▶ **Treated wastewater**
- ▶ **Treated soil**
- ▶ **Non-contact furnace exhaust gas**
- ▶ **Filtration elements**
- ▶ **Catalyst**

APPLICABILITY OF LTTD SYSTEMS

(CONTINUED)

- ▶ The presence of materials which tend to inhibit heat transfer by fouling or plugging should be considered relative to the LTTD system design
- ▶
- ▶ Large solid masses of contaminated media, such as large boulders or material that clumps, may not be treatable due to lack of uniform heat transfer

OVERVIEW OF VARIOUS TYPES OF LTTDs

SELECT LTTD TECHNOLOGIES

Continuous

(Ex Situ)

Direct Fired

- ▶ Rotary Dryer
- ▶
- ▶

Indirect Fired

- ▶ Rotary Dryer
- ▶ Thermal Screw Conveyor

Batch

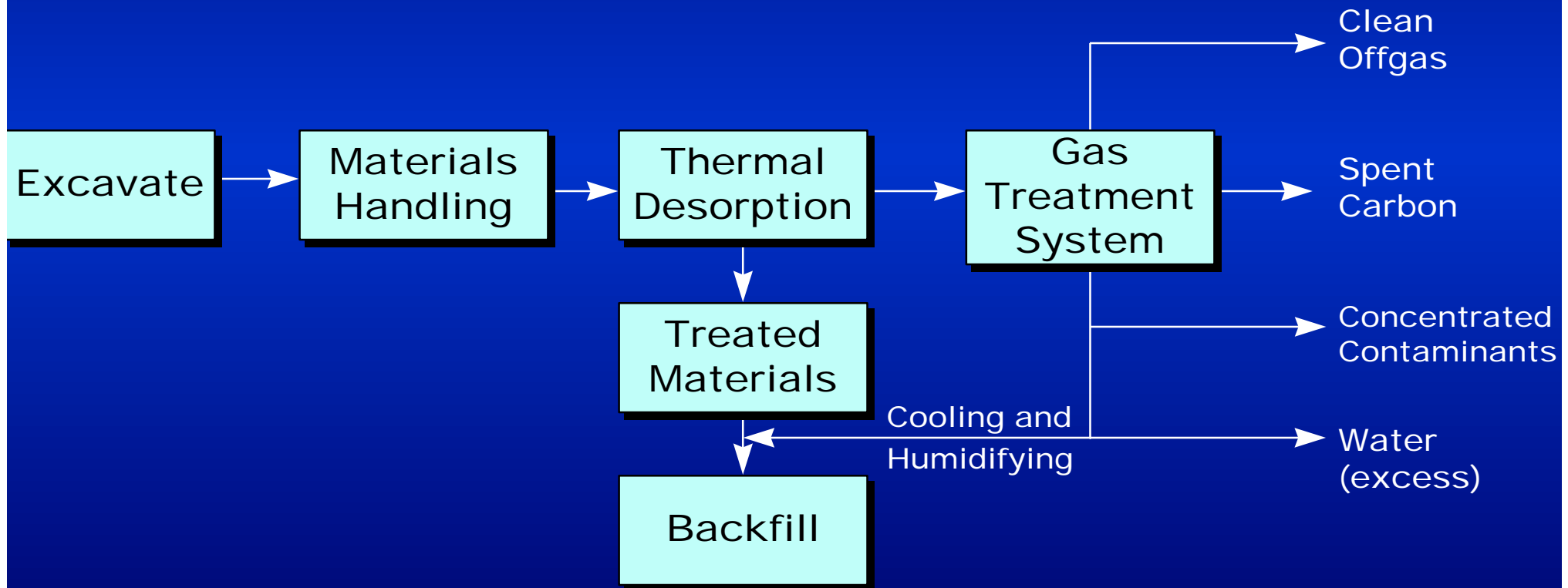
Ex Situ

- ▶ Heated Oven
- ▶ Hot Air Vapor Extraction (HAVE)
- ▶

In Situ

- ▶ Thermal Blanket
- ▶ Thermal Well

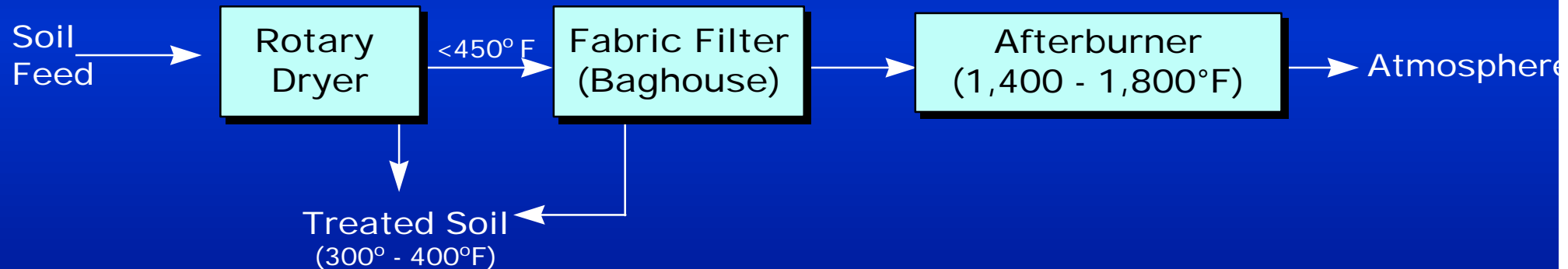
GENERALIZED SCHEMATIC DIAGRAM OF EX SITU LTTD PROCESS



DIRECT FIRED LTTD SYSTEMS

FIRST GENERATION

for low boiling point, non-chlorinated contaminants



DIRECT FIRED LTTD

(10 - 25 TONS PER HOUR)

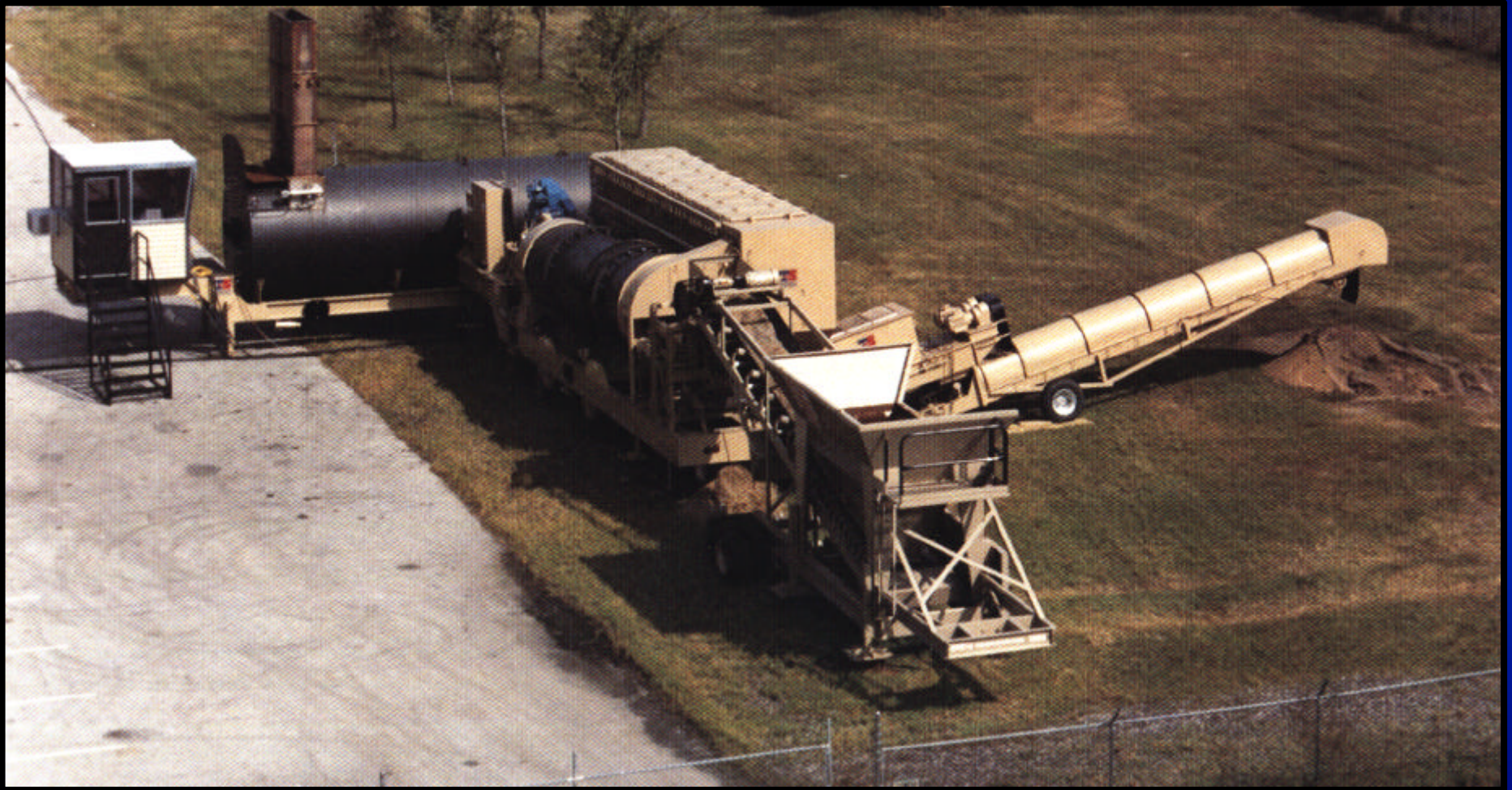


Photo Courtesy of ThermoTech Systems Corp., Orlando, FL

DIRECT FIRED LTTD (40 - 100 TONS PER HOUR)

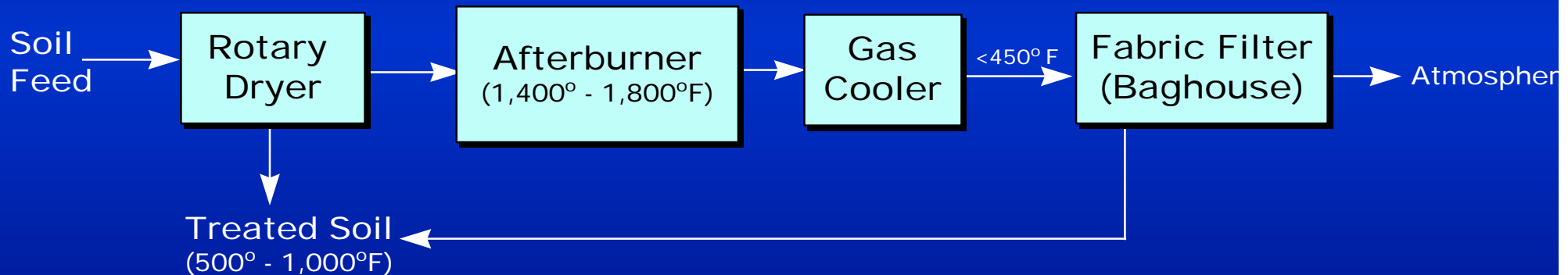


Photo Courtesy of CMI Corporation, Oklahoma City, OK

DIRECT FIRED LTTD SYSTEMS

SECOND GENERATION

for higher boiling point, non-chlorinated contaminants



DIRECT FIRED LTTD (40 - 160 TONS PER HOUR)

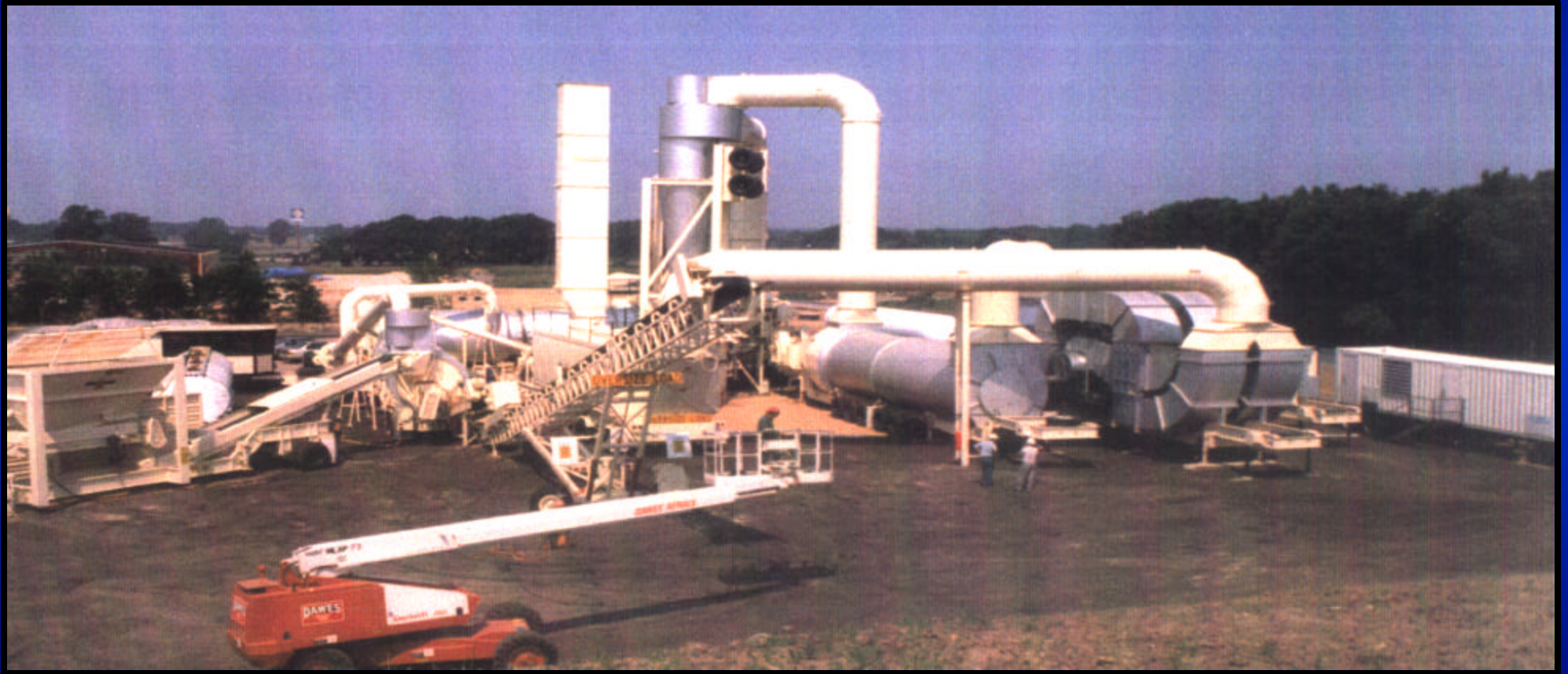
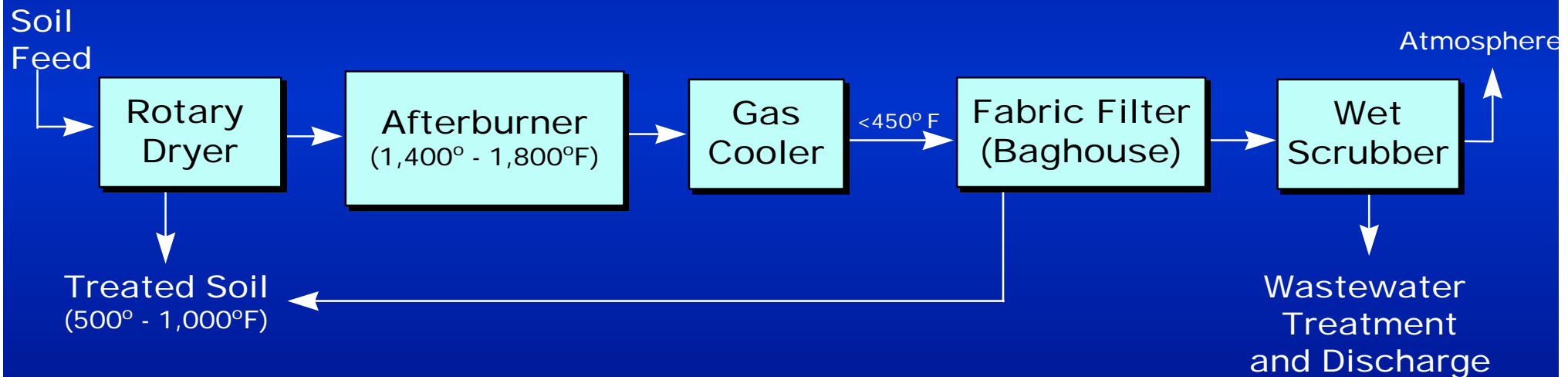


Photo Courtesy of CMI Corporation, Oklahoma City, OK

DIRECT FIRED LTTD SYSTEMS

THIRD GENERATION

for high boiling point, chlorinated contaminants



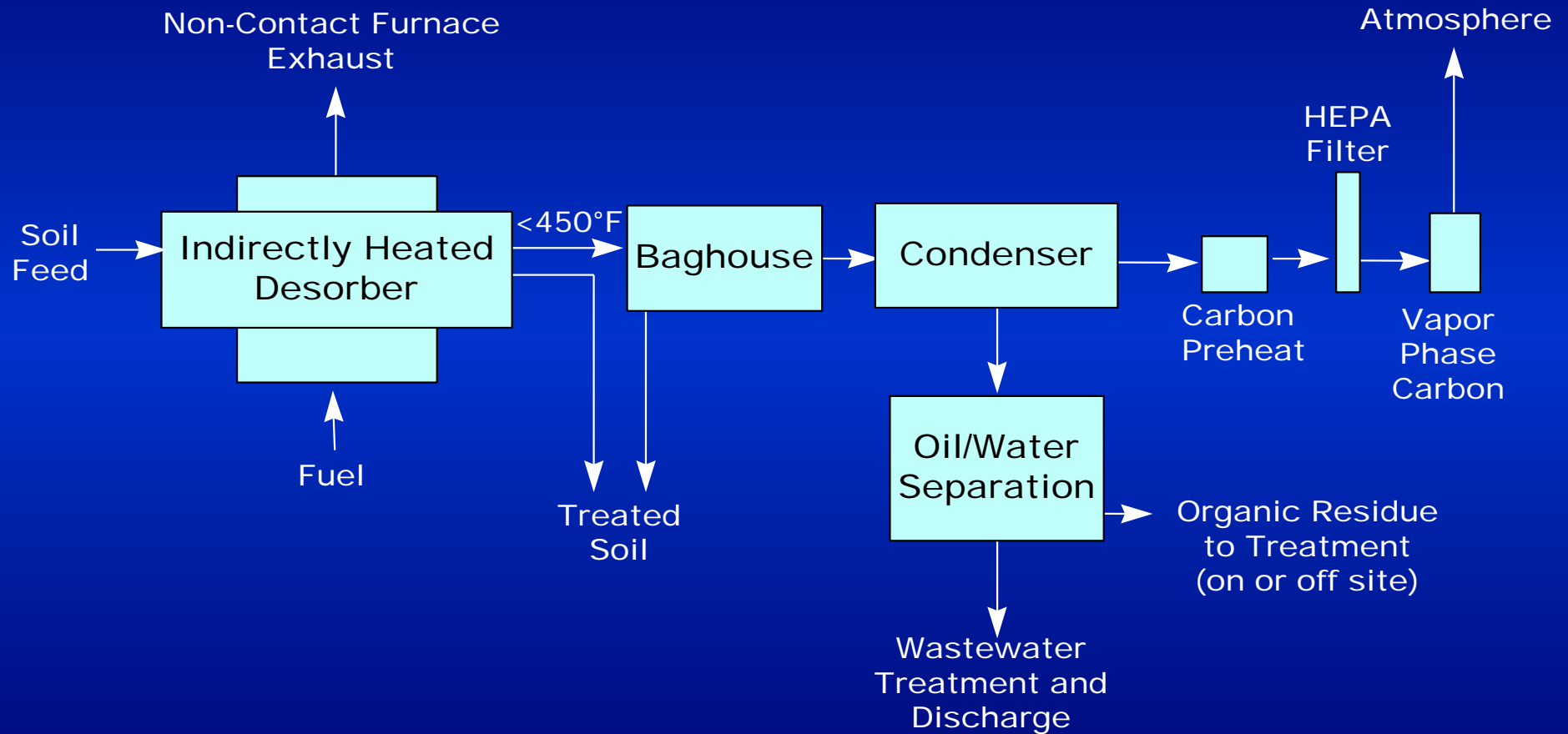
AMERICAN THERMOSTAT SITE SOUTH CAIRO, NY



AMERICAN THERMOSTAT SITE SOUTH CAIRO, NY



INDIRECT FIRED LTTD SYSTEMS (TYPICAL)



INDIRECT FIRED LTTD

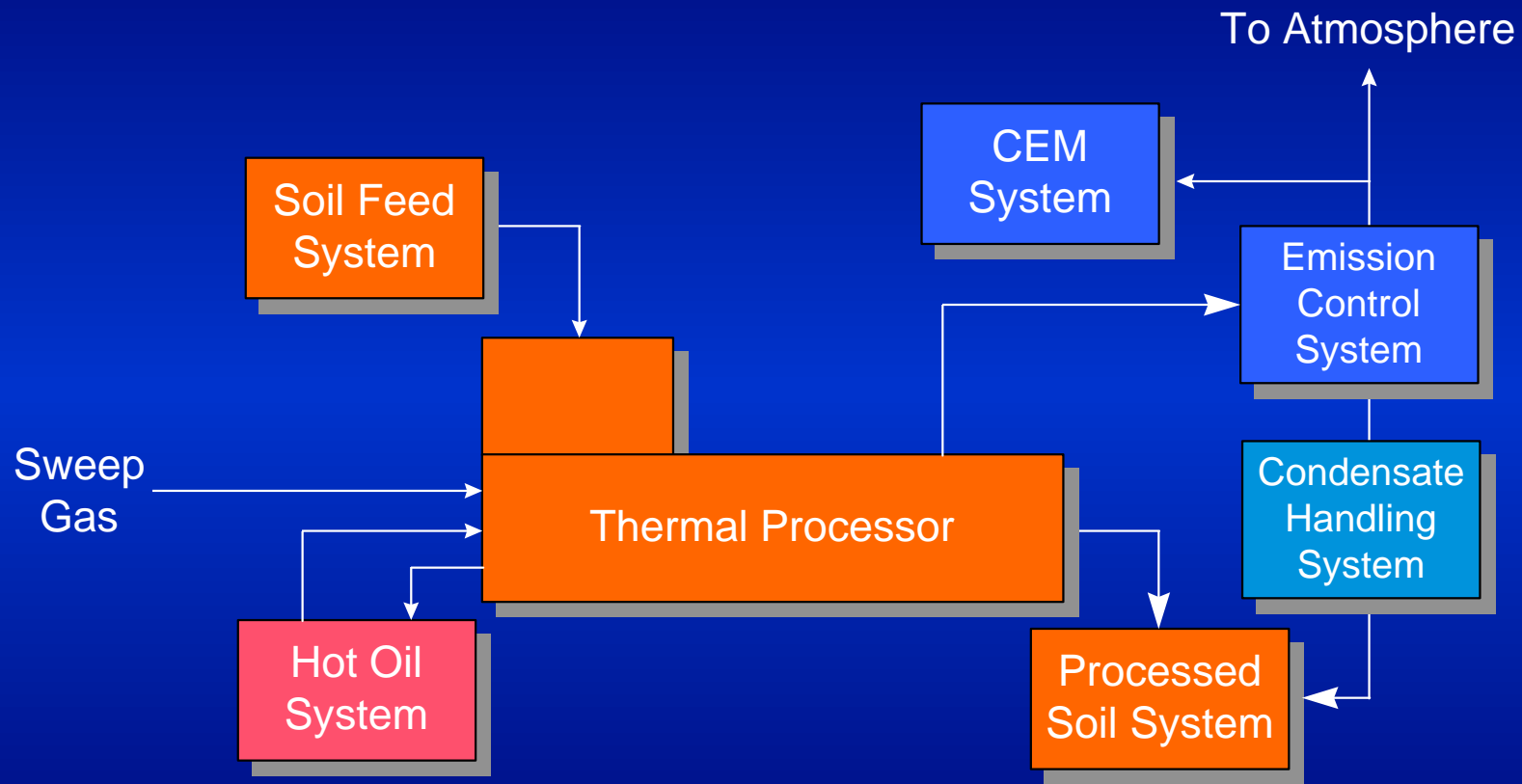


Photo Courtesy of Maxymillian Technologies, Pittsfield, MA

BASE CATALYZED DECOMPOSITION PROCESS (BCDP) FOR PCB-CONTAMINATED SOIL REMEDIATION ON GUAM

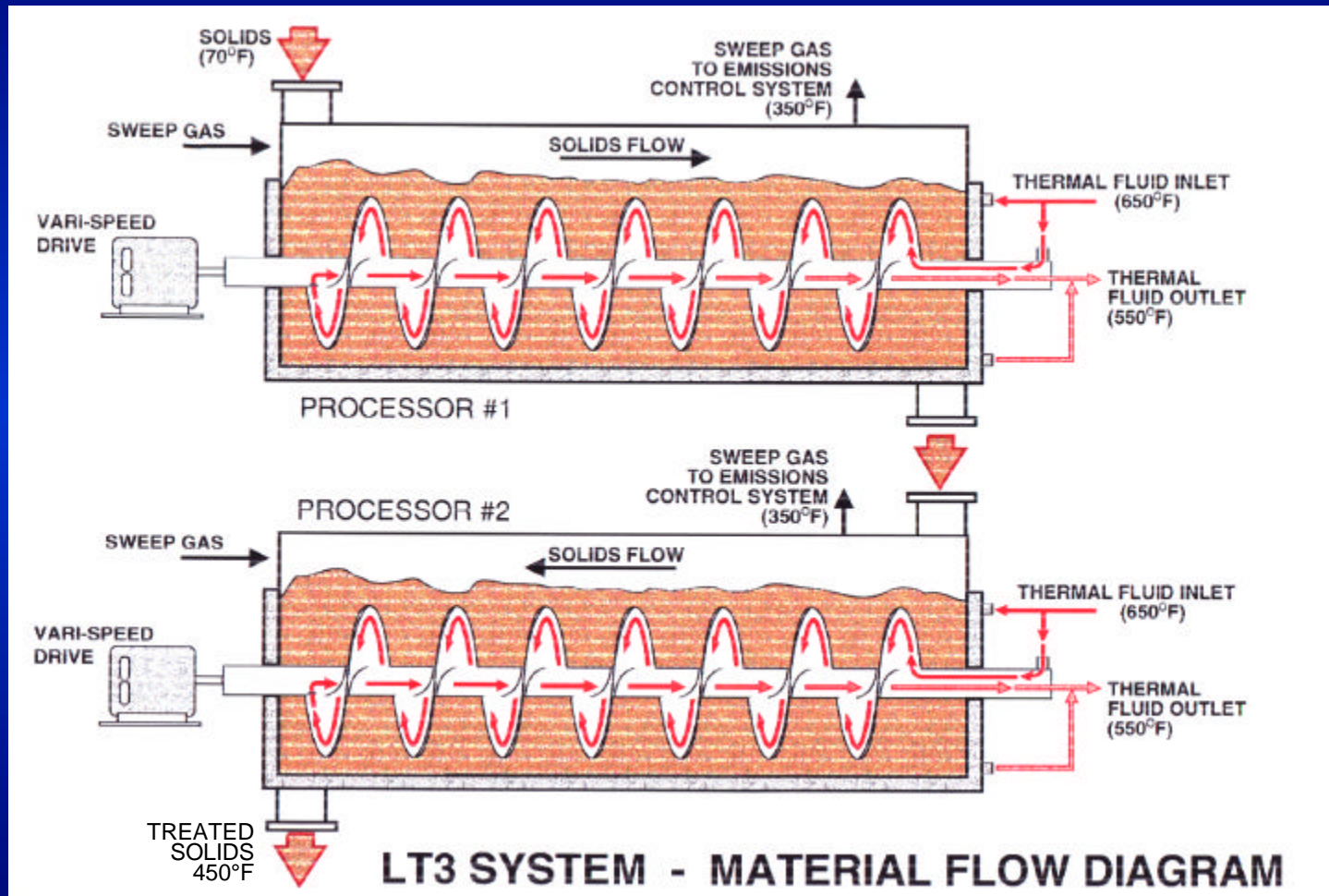


INDIRECT FIRED THERMAL SCREW (TYPICAL)



Courtesy of Roy F. Weston, West Chester, PA

INDIRECT FIRED THERMAL SCREW (TYPICAL)

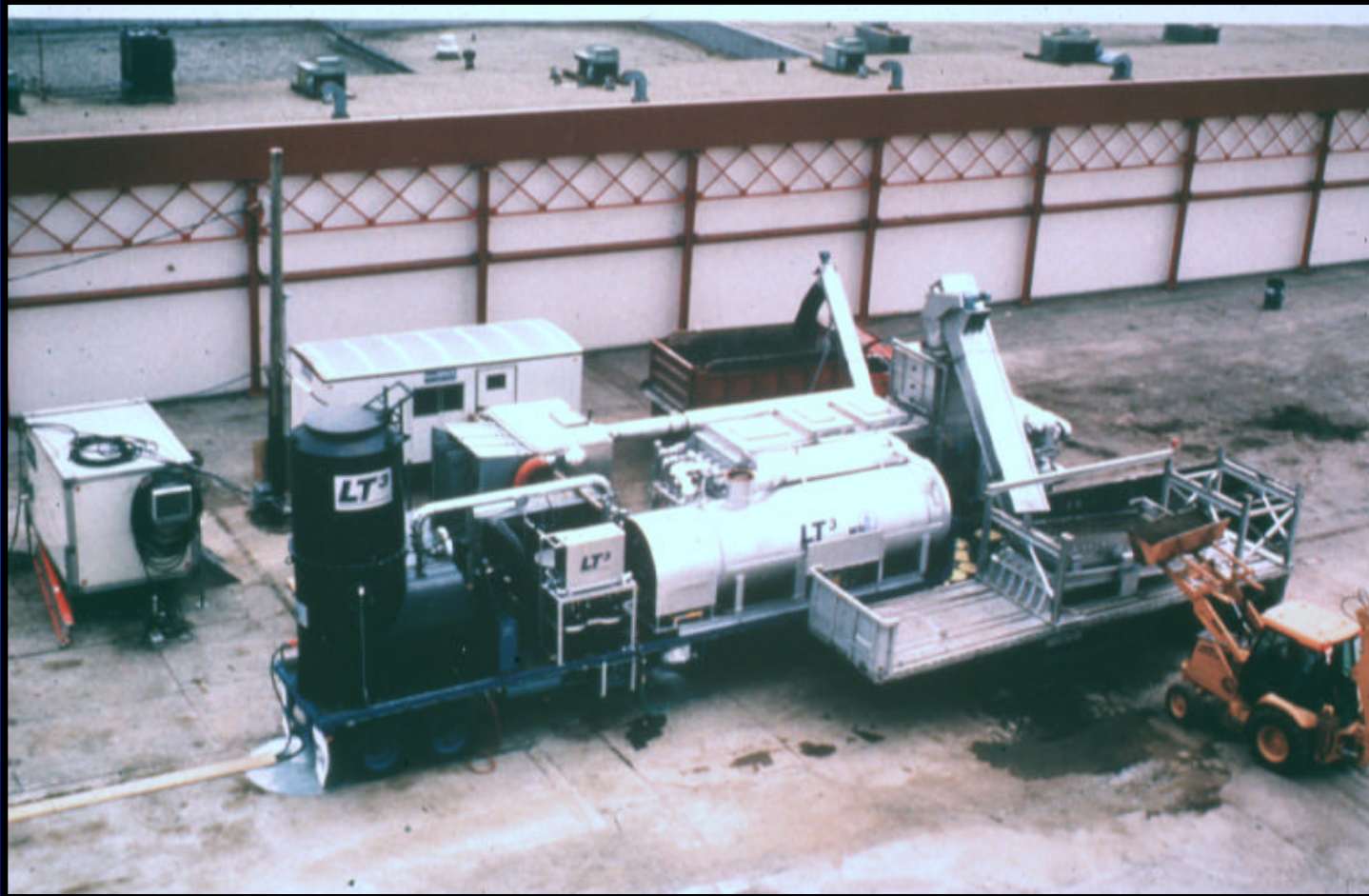


Counter
Flow

Co-current
Flow

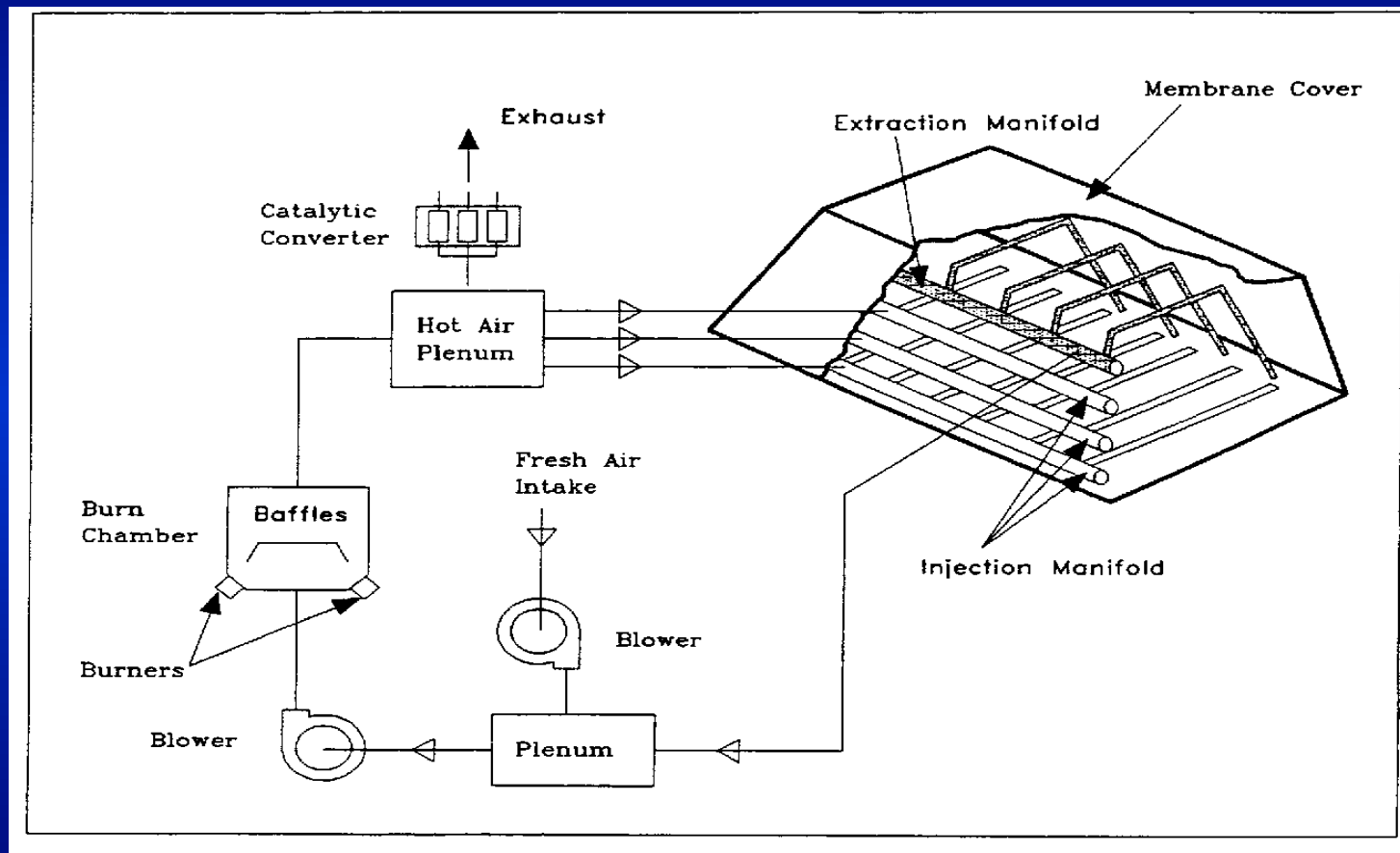
Courtesy of Roy F. Weston, West Chester, PA

INDIRECT FIRED THERMAL SCREW SYSTEM



Courtesy of Roy F. Weston, West Chester, PA
(scene from Naval Auxiliary Landing Field project at Crows Landing, CA)

HOT AIR VAPOR EXTRACTION (HAVE) SYSTEM SCHEMATIC DIAGRAM

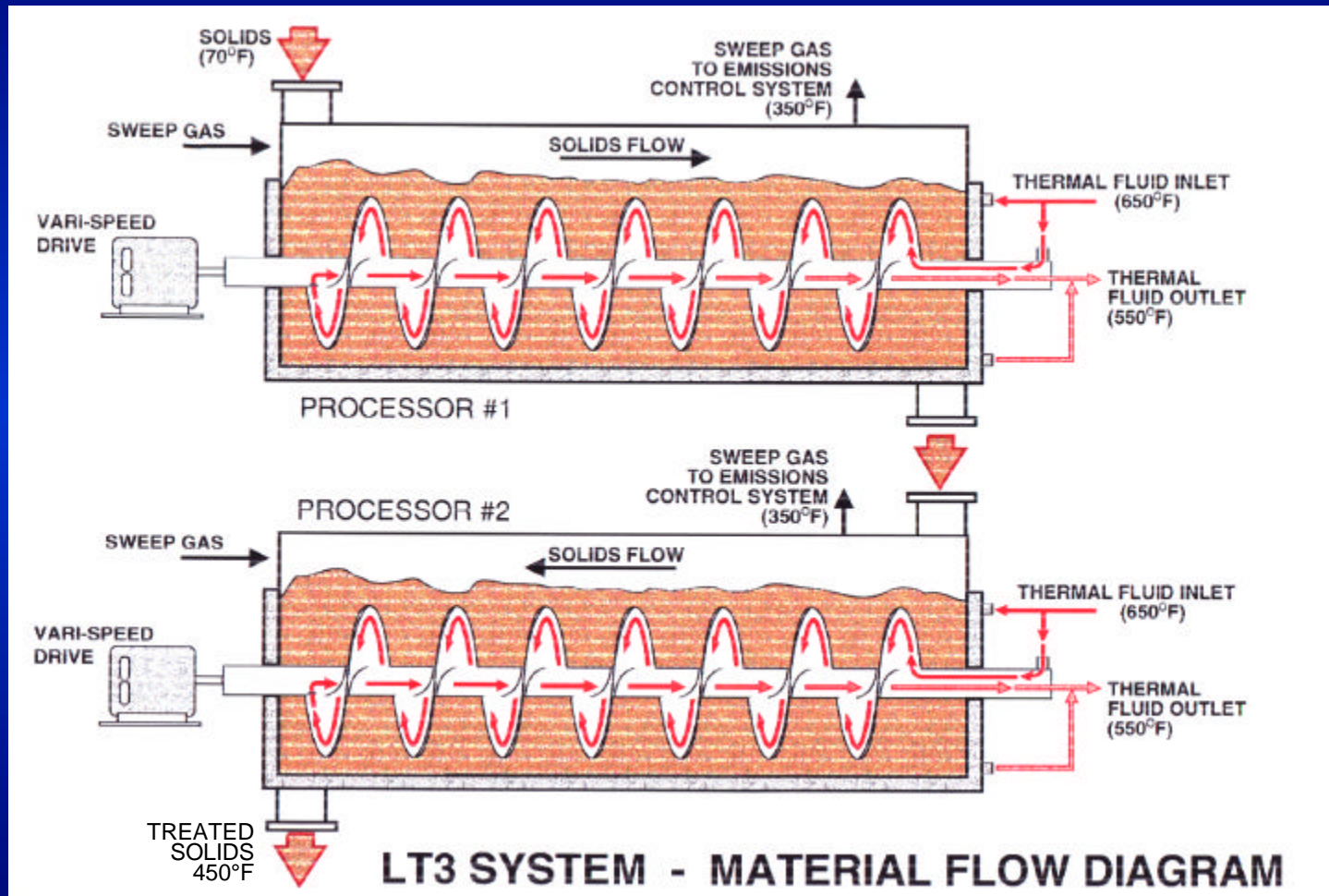


Source: Technical Report TR-2066-ENV
Naval Facilities Engineering Service Center, Port Hueneme, CA

***HAVE* SYSTEM DEMONSTRATION FOR FUEL HYDROCARBON CLEANUP AT PORT HUENEME, CA**



INDIRECT FIRED THERMAL SCREW (TYPICAL)

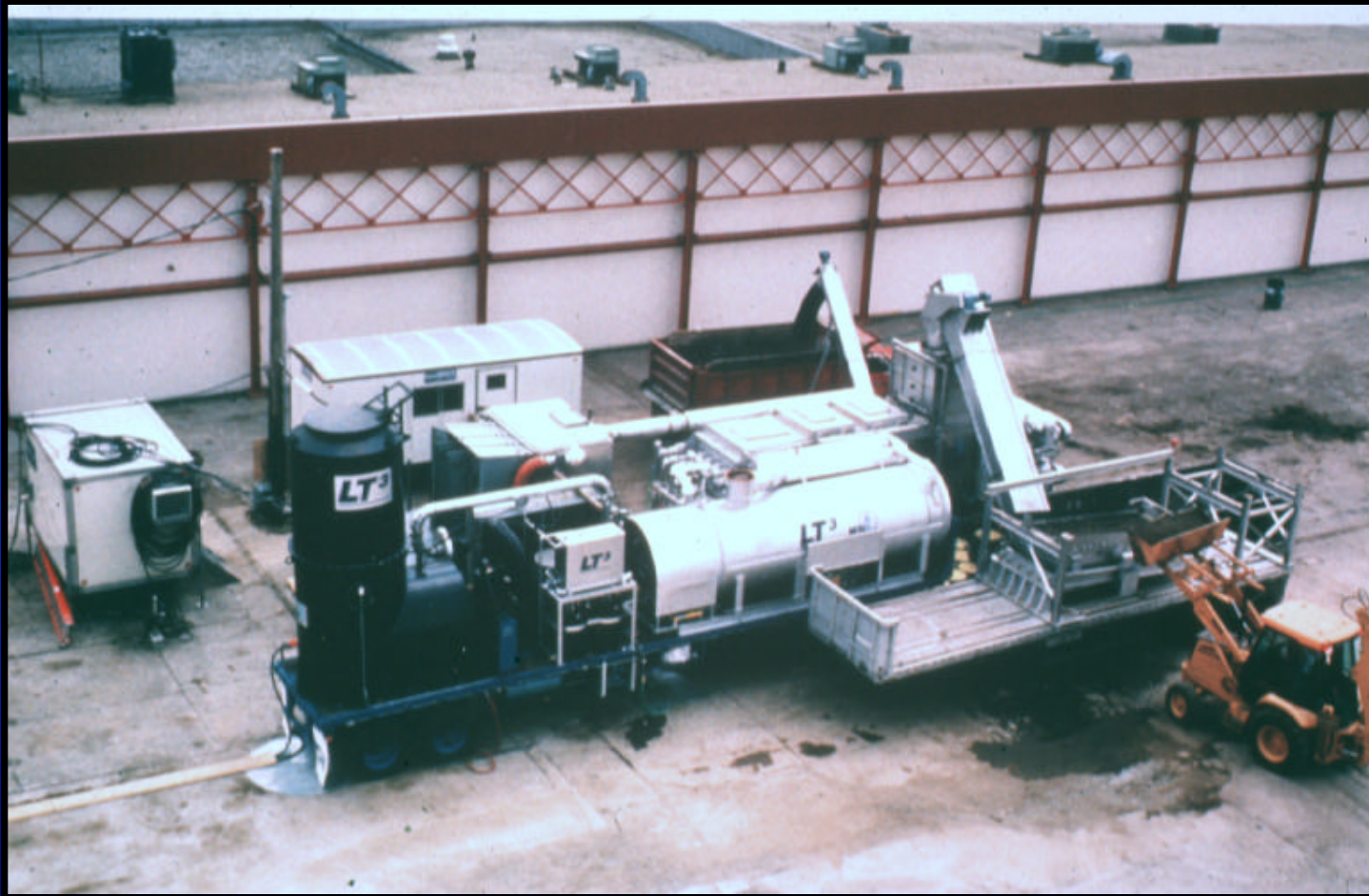


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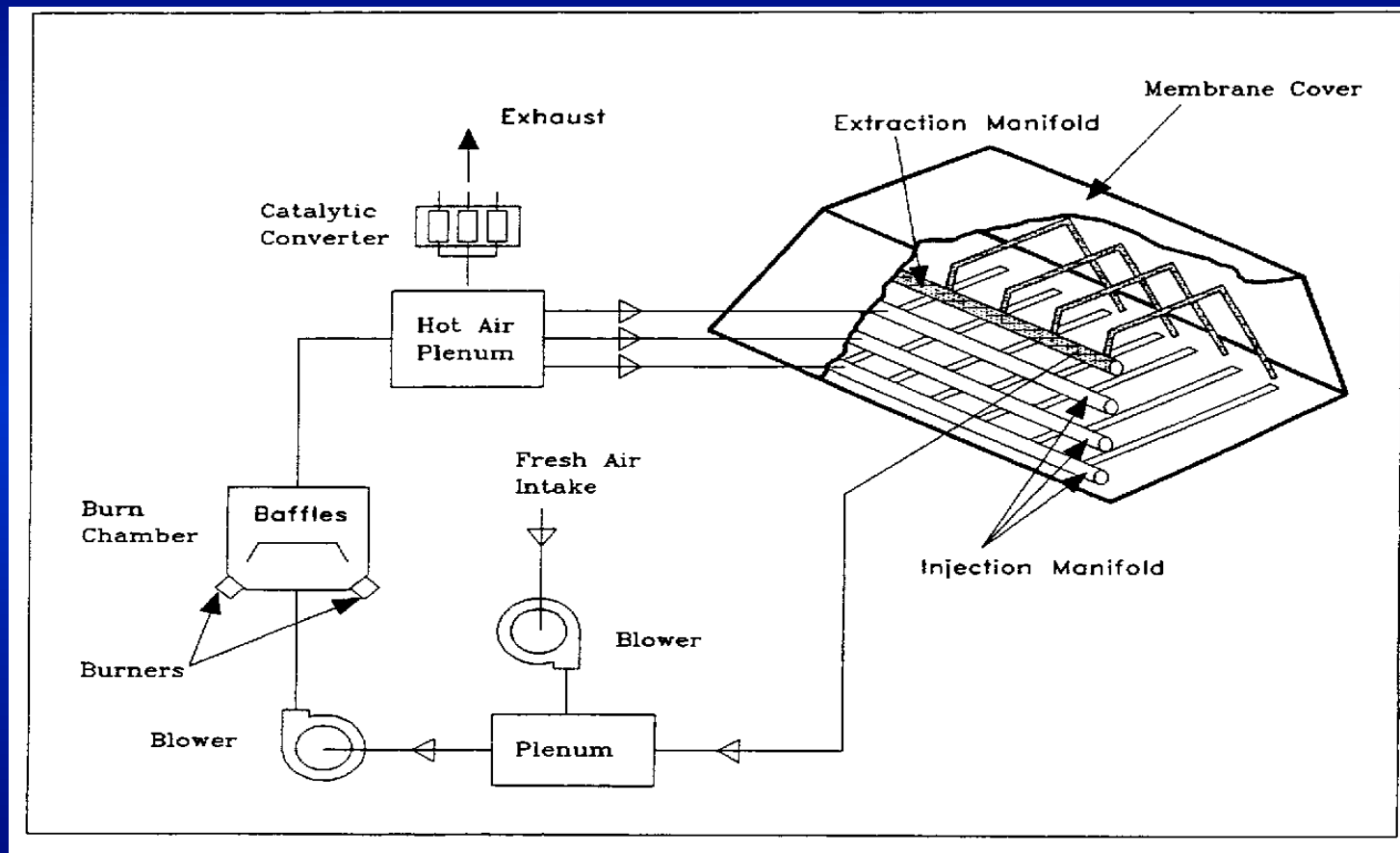
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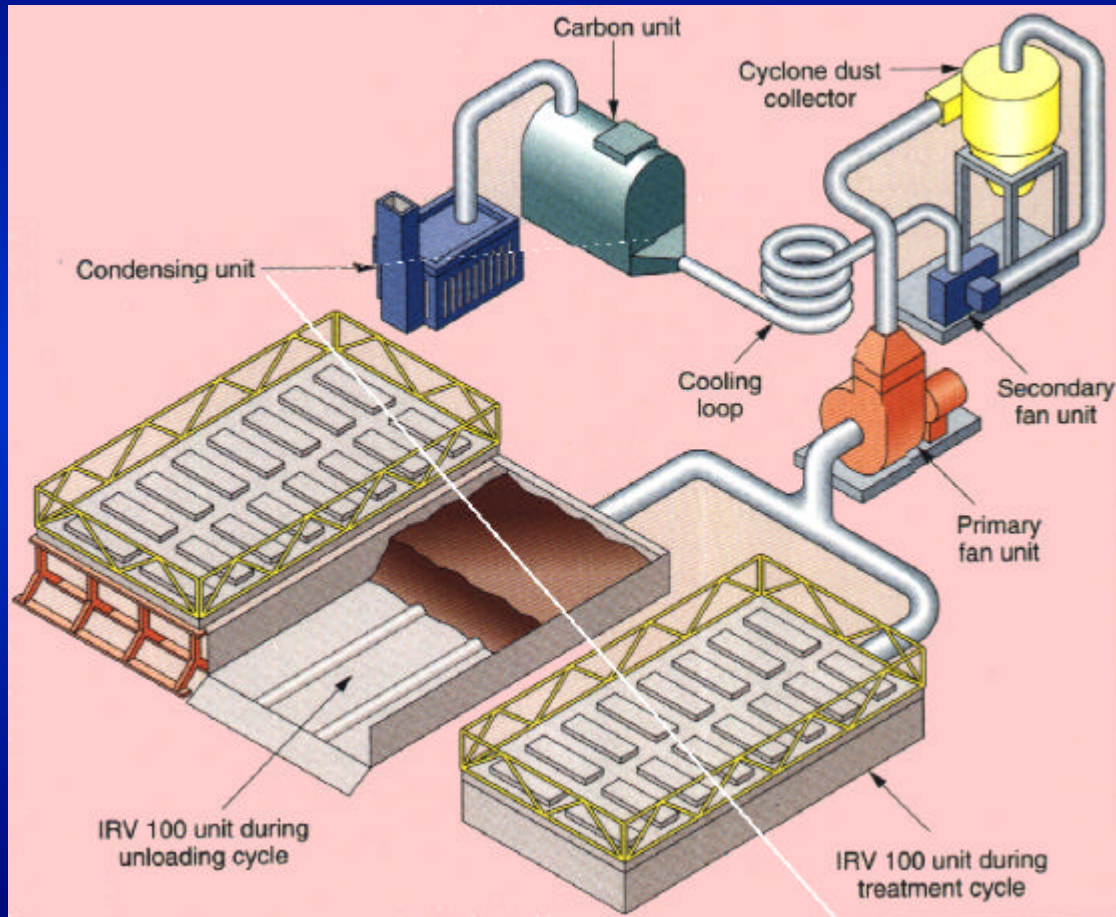


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***HAVE* SYSTEM DEMONSTRATION FOR FUEL HYDROCARBON CLEANUP AT PORT HUENEME, CA**



EX SITU BATCH LTTD SYSTEM FIRST GENERATION



**Infrared heat,
vacuum system
IRV-100**

Schematic Courtesy of McLaren Hart, Warren, NJ

EX SITU BATCH LTTD SYSTEM

TERRACHEM IRV-100



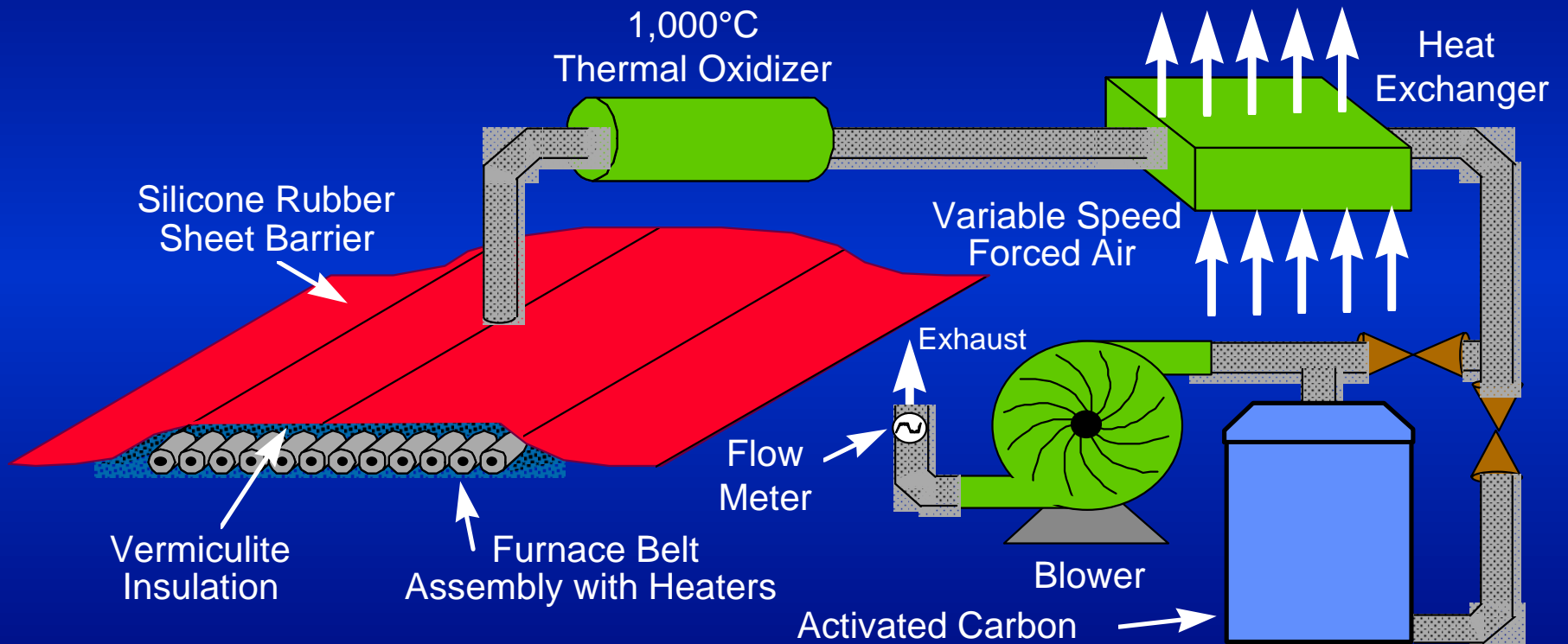
Photo Courtesy of McLaren Hart, Warren, NJ

TERRACHEM IRHV-200 FCX SUPERFUND SITE



Photo Courtesy of McLaren Hart, Warren, NJ

IN SITU LTTD SYSTEM THERMAL BLANKET SCHEMATIC



Schematic Courtesy of Terratherm Environmental Services, The Woodlands, TX

A THERMAL BLANKET IS LOWERED ONTO A CONTAMINATED SITE.

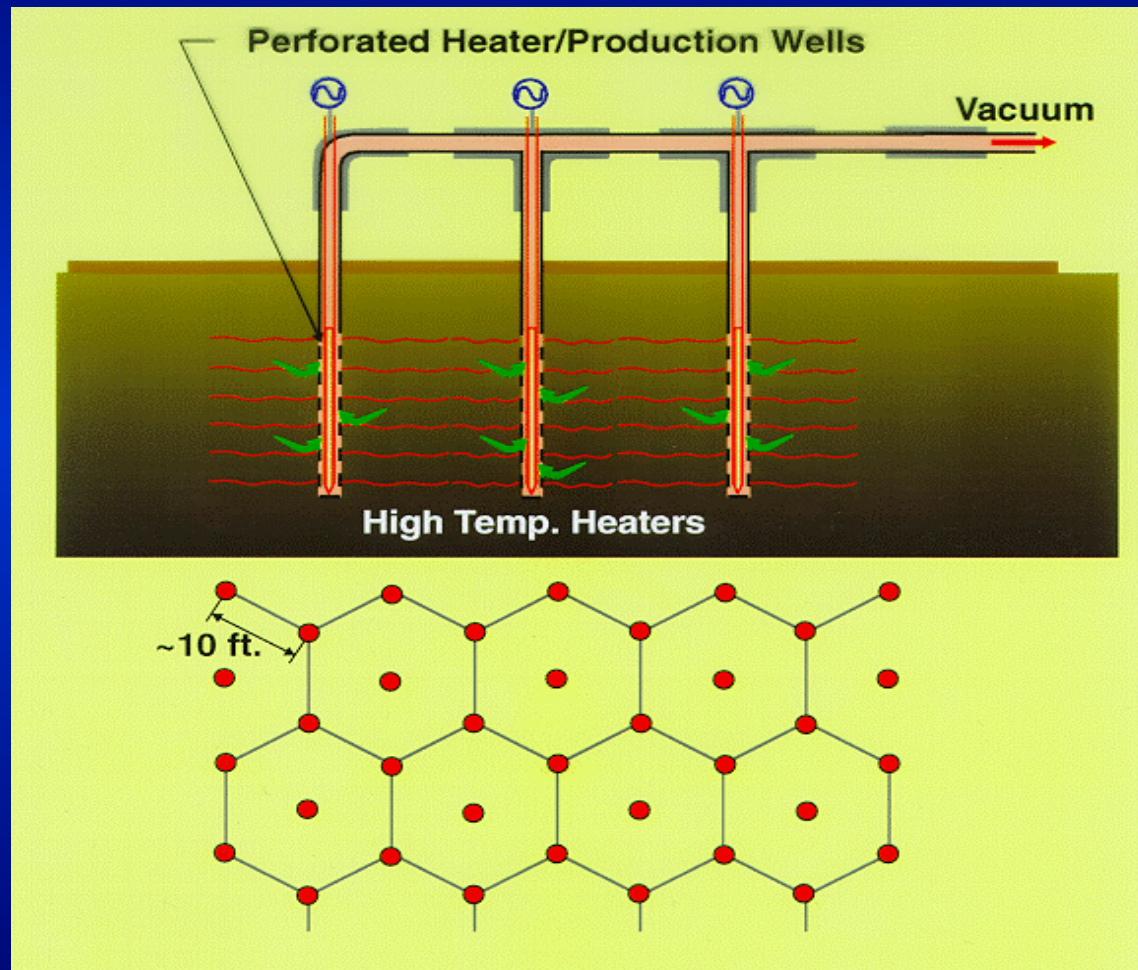




THERMAL BLANKET PILOT

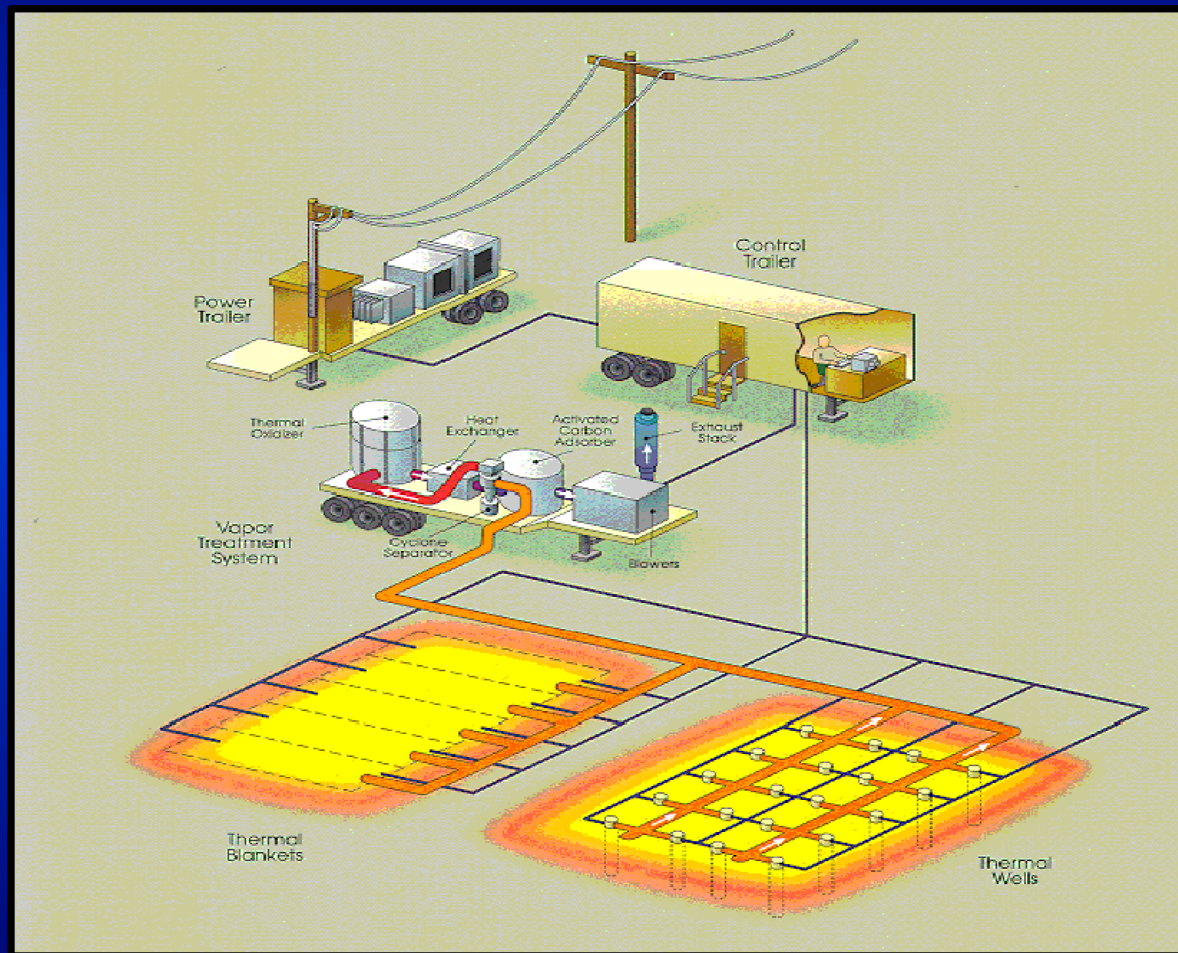


IN SITU LTTD SYSTEM THERMAL CONDUCTION WELLS



Schematic Courtesy of Terratherm Environmental Services, The Woodlands, TX

IN SITU LTTD SYSTEM THERMAL BLANKET/WELL COMBINATION



Schematic Courtesy of Terratherm Environmental Services, The Woodlands, TX

IN SITU THERMAL DESORPTION THERMAL WELLS INSTALLATION



Photo Courtesy of Terratherm Environmental Services, The Woodlands, TX

DESIGN AND PERFORMANCE CHARACTERISTICS

WASTE CHARACTERIZATION

- ▶ **Soils are inherently variable in their physical and chemical characteristics**
- ▶ **Physical characteristics needed:**
 - Soil particle size distribution
 - Composition (sand, clay, silts, rocks, etc.)
 - Bulk density
 - Permeability (water and/or air)
 - Plasticity (measures tendency to clump and stick)
 - Soil “in-place” homogeneity (impermeable layers etc.)

WASTE CHARACTERIZATION

(CONTINUED)

- ▶ **Chemical characteristics needed:**
 - **Moisture Content**
 - **Heat Content**
 - **Contaminant Type, Concentration, and Distribution**
 - **Halogen Content**
 - **Metals Concentrations (Total and TCLP)**
 - **Alkali Salt Content**

DESIGN CHARACTERISTICS

CONTINUOUS LTTD/HTTD TECHNOLOGIES

Item	Direct Fired Rotary Dryer	Indirect Fired Rotary Dryer	Indirect Fired Thermal Screw
Soil Feed Maximum Size	< 2 "	< 2 "	< 2 "
Heat Source	Direct Contact Combustion	Indirect Contact Combustion	Indirect Contact Hot Oil/Steam
Treated Soil Temperature Range	300° - 1,000°F	250° - 1,000°F	200° - 450°F
Feed Rate Achievable	20 to 160 tph	10 to 20 tph	5 to 10 tph
Mobilization Time Required	1 to 4 weeks depending on size	1 to 2 weeks	1 to 2 weeks
Layout Area Required (Thermal Treatment System Only)	Small: 75 ft. x 100 ft. Large: 150 ft. x 200 ft.	70 ft. x 80 ft.	50 ft. x 100 ft.

DESIGN CHARACTERISTICS

BATCH LTTD TECHNOLOGIES

	Ex Situ Heated Oven	HAVE System	Thermal Blanket	Thermal Well
Soil Feed Maximum Size	< 2 "	NA	NA	NA
Heat Source	Indirect Contact Combustion	Direct Contact Combustion	Electric Resistance Heater	Electric Resistance Heater
Treat Soil Temperature Range	200° - 500°F (Note: Vacuum reduces boiling point effective up to approx. 750°F)	150° - 400°F	200° - 500°F (estimated average bulk temperature)	200° - 500°F (estimated average bulk temperature)
Batch Size	One Chamber 5 - 20 cu. yds.	300 - 1,000 cu. yds. Optimum: 750 cu. yds.	One Module: 8 ft. x 20 ft.	NA
Treatment Time	1 to 4 hrs. per batch	12-14 days	4 days	Unknown
Mobilization Time Required	1 week	2 to 7 days	Not available	Not available
Layout Area Required (Thermal Treatment System Only)	40 ft. x 100 ft. (4-unit setup)	40 ft. x 100 ft for 750 cu. yds.	Variable	Variable depending on number of wells

PERFORMANCE CHARACTERISTICS

- ▶ **Performance varies by type of unit, site characteristics, and contaminants**
- ▶ **In general, all units can meet regulatory criteria**
- ▶ **Batch systems take longer**
- ▶ **Direct fired systems generally provide significantly lower residual concentrations, usually below detectable levels**

COST INFORMATION

COST FACTORS TO CONSIDER

- ▶ **Project Planning**
- ▶ **Project Work Plans and Submittals**
- ▶ **Regulatory Issues and Permitting**
- ▶ **Site Layout, Preparation, Mobilization, and Demobilization**
- ▶ **System Start-up and Performance Testing**
- ▶ **Unit Treatment Cost for a Range of Quantities**
- ▶ **Contaminated Soil Excavation, Material Handling, Processing, and Backfill**
- ▶ **Sampling and Analysis (Excavation, Treated Soils, Air Monitoring, Water Discharge, etc.)**
- ▶ **Site Restoration**

LTDD TECHNOLOGIES

TYPICAL COST INFORMATION FROM LITERATURE *(treatment cost only)*

Continuous

- | | |
|--|---------------------|
| ▶ Small - Medium Direct Fired Rotary Dryer | \$40-\$200 per ton |
| ▶ Large Direct Fired Rotary Dryer | \$35-\$100 per ton |
| ▶ Indirect Fired Rotary Dryer | \$80-\$150 per ton |
| ▶ Indirect Fired Thermal Screw | \$100-\$150 per ton |
| ▶ BCDP | \$322 per ton |

Batch

- | | |
|------------------------|-------------------------------|
| ▶ Heated Oven | \$120-\$250 per ton |
| ▶ HAVE | \$48-\$51 per ton (estimated) |
| ▶ | |
| ▶ Thermal Blanket/Well | roughly \$100 per ton |

EXAMPLE:
NAVAL STATION MAYPORT
JACKSONVILLE, FLORIDA

NAVAL STATION MAYPORT

SWMUs 6 & 7 - PROCESS

- ▶ **Front-end loader feeds petroleum contaminated soil into 3-CY cold feed bin**
- ▶ **Conveyor transports contaminated soil into rotary dryer**
- ▶ **Rotary dryer - 4' diameter by 20' long - elevates soil temperature to 650°-700°F with residence time of 6-10 minutes - moisture and volatile organic compounds are volatilized**
- ▶
- ▶ **High Temperature Baghouse removes soil fines and dust particles from dryer chamber exhaust gases**
- ▶ **Screw Auger mixes dust (collected from baghouse) with discharged from rotary dryer**

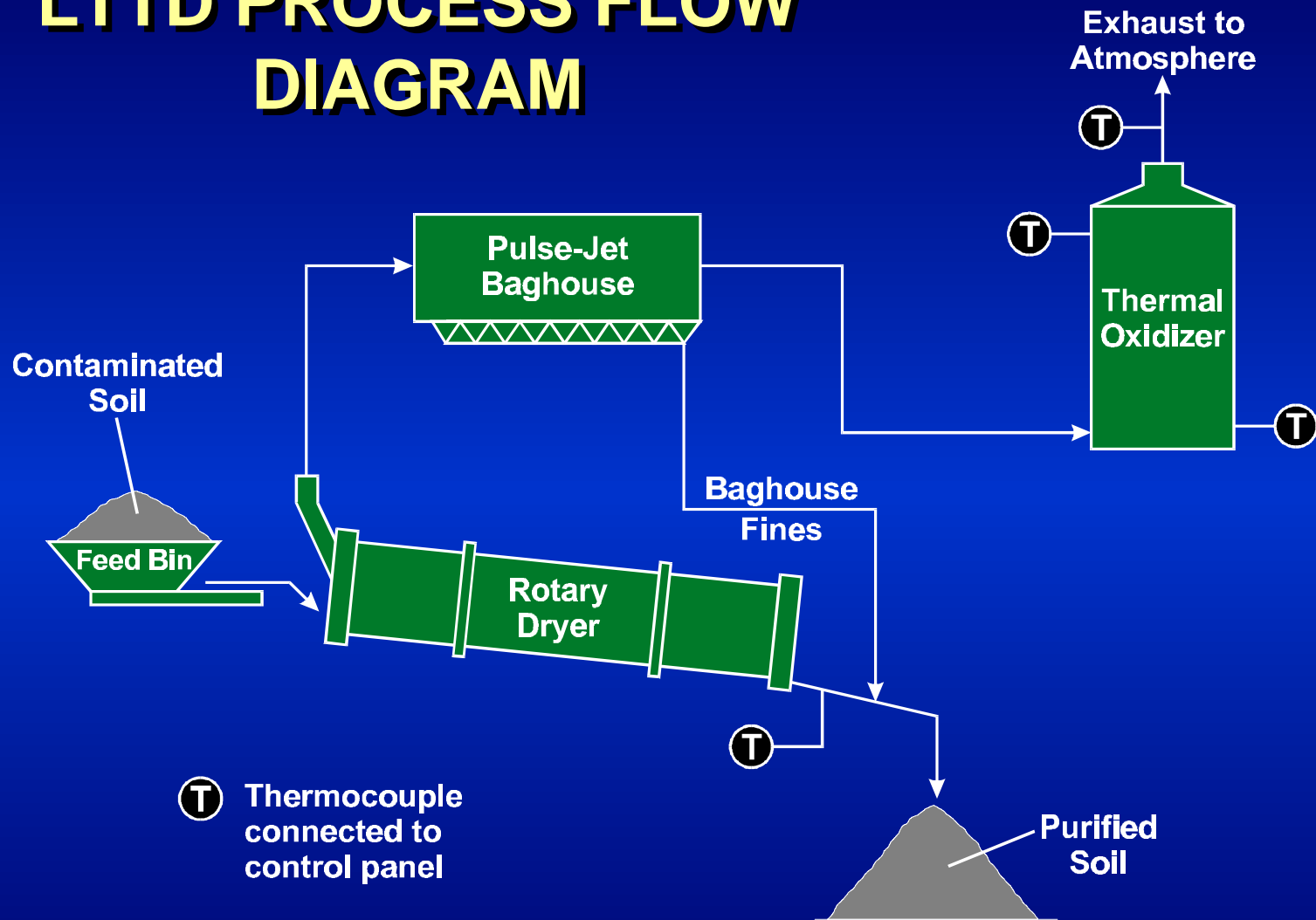
NAVAL STATION MAYPORT

SWMUs 6 & 7 - PROCESS

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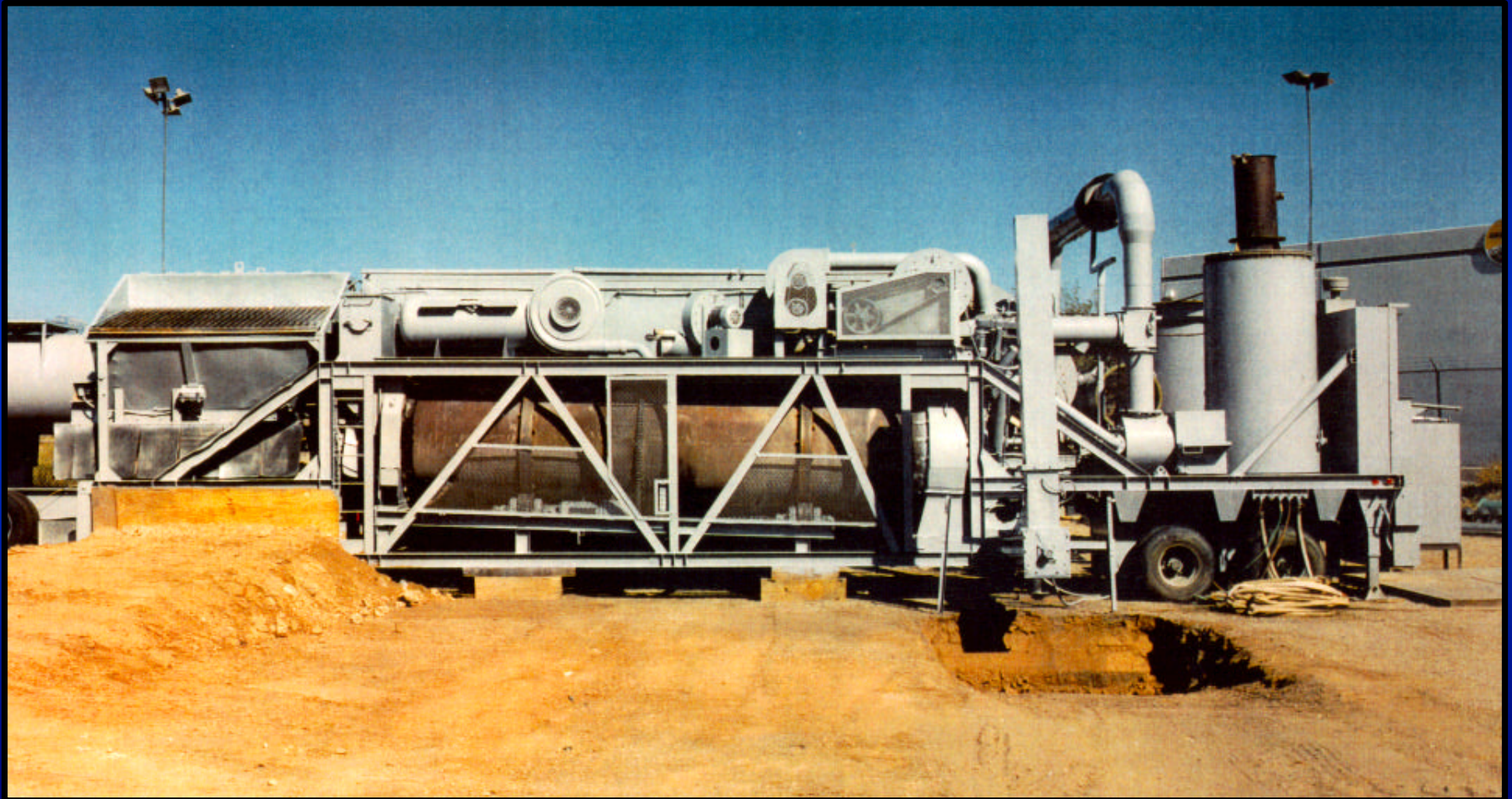
- ▶ **Soil rehydrated at discharge to minimize dust and prepare for use as backfill**
- ▶ **Thermal Oxidizer combusts volatile organic compounds from particle-free exhaust gases - minimum 1,500°F with minimum 1 second retention time**
- ▶
- ▶ **Treated air emitted to atmosphere**
- ▶ **Soil input proposed at 8-12 tons per hour**
- ▶ **Treated 2,400 tons**
- ▶ **Cost - \$198,000 including planning, excavating, treating, returning soil into place**

LTTD PROCESS FLOW DIAGRAM



Source: Southwest Soil Remediation, Inc.

LTTD EQUIPMENT - 4' PLANT



Source: Southwest Soil Remediation, Inc.

EXAMPLE:
AMERICAN THERMOSTAT SITE
SOUTH CAIRO, NY

AMERICAN THERMOSTAT SITE

SOURCE CONTROL REMEDIATION QUANTITIES

- ▶ **Phase I - Approximately 13,000 CY***
- ▶ **Phase II - Approximately 26,000 CY***

*Quantity Values Reflect the Payment Basis of In-Place Volume,
in Cubic Yards (CY)

AMERICAN THERMOSTAT SITE SCOPE OF WORK

- ▶ Mobilization and Site Preparation
- ▶ Excavation and Shoring & Bracing of Sidewalls
- ▶ Waste Feed Preparation
- ▶ LTTD Processing of Approximately 13,000 CY (Phase I) and Approximately 26,000 CY (Phase II)
- ▶ Backfill of Treated Soils Onsite
- ▶ Provide and Operate Water Treatment System
- ▶ Demobilization and Site Restoration

AMERICAN THERMOSTAT WASTE CHARACTERIZATION DATA

Contaminant	Range of Concentration (ppm)
-------------	------------------------------

▶
Organic Compounds

Trichloroethene (TCE)	N.D. to 1.1
Tetrachloroethene (PCE)	N.D. to >10,000
Misc. Other Organic Compounds	N.D. to 1.0

▶
Inorganic Compounds

Lead (Pb)	95 to 119
Cadmium (Cd)	1.0 to 1.5

AMERICAN THERMOSTAT SITE

SOURCE CONTROL REMEDIATION TRANSITION FROM PHASE I TO PHASE II

- ▶ Identification of up to 30,000 CY of additional soil to be treated
- ▶ Government consideration of validity of sole source procurement
- ▶ Solicitation of bid from existing (Phase I) LTTD subcontractor
- ▶ Negotiation and re-bids received from existing LTTD subcontractor

AMERICAN THERMOSTAT SITE
SOURCE CONTROL REMEDIATION TRANSITION
FROM PHASE I TO PHASE II
(CONTINUED)

- ▶ Decision to solicit competitive proposals through advertised bidding process
- ▶ Best and final offers from competitive offerors
- ▶ Award of new LTTD subcontract for up to 30,000 CY of soil treatment

**AMERICAN THERMOSTAT SITE
PHASE II SOIL REMEDIATION
SOLE SOURCE ADD-ON
VS.
OPEN RE-PROCUREMENT**

- ▶ Savings of about \$3.5 MM due to competitive re-bid
- ▶ Apparent delay of nearly 6 months in initial schedule due to re-procurement
- ▶ Phase II LTDD subcontractor processing rate more than double Phase I vendor. Therefore, no overall schedule delay was actually incurred.

AMERICAN THERMOSTAT SITE

SUMMARY OF LTTD SUBCONTRACT AWARDS

- ▶ **Phase I: 13,000 CY (20,800 tons) = \$3.77 MM**
Soil Treatment Cost (only) = \$51.74/ton
- ▶ **Phase II: 30,000 CY (48,000 tons) = \$6.54 MM**
Soil Treatment Cost (only) = \$34.38/ton

AMERICAN THERMOSTAT SITE

COST INFORMATION (AS BID IN YEAR SHOWN)

Phase I (1992): 13,000 cubic yards (20,800 tons)

Bidders	A	B	C	D	E	F	Average
Soil Treatment Cost (\$/ton)	\$51.74	\$68.13	\$81.36	\$38.75	\$91.56	\$42.50	\$62.34
Overall Cost (\$/ton)	\$181.25	\$234.23	\$210.96	\$214.98	\$323.49	\$228.17	\$232.16

Phase II (1995): 30,000 cubic yards (48,000 tons)

Bidders	1	2	3	4	5	6	7	8	9	Average
Soil Treatment Cost (\$/ton)	\$52.54	\$43.66	\$67.44	\$33.04	\$62.50	\$34.38	\$36.25	\$75.34	\$22.81	\$47.55
Overall Cost (\$/ton)	\$199.85	\$158.20	\$230.29	151.29	\$261.82	\$136.25	\$154.61	\$225.63	\$172.77	\$187.80

AMERICAN THERMOSTAT SITE COST INFORMATION

- ▶ **Soil treatment cost is within range reported in literature**
- ▶ **In general, the larger the quantity to be treated, the lower the unit rate, provided LTDD system size is compatible with the quantity to be treated**
- ▶ **Overall cost includes Unit Rate plus the following other site costs:**
 - **Site Preparation, Mobilization, Demobilization, and Site Support Services**
 - **Health and Safety, Air Monitoring, Sampling and Analysis**
 - **Excavation, Shoring, Backfill**
 - **Treated Soil Stabilization**
 - **Site Restoration**

LESSONS LEARNED SUMMARY

AMERICAN THERMOSTAT SITE

AMERICAN THERMOSTAT SITE LESSONS LEARNED SUMMARY

- ▶ **Need full-time, on-site LTTD Project Manager**
- ▶ **Consider re-bid for significant quantity growth**
- ▶ **Specify pertinent regulatory parameters directly**
- ▶ **Material handling / waste feed preparation are key activities**
- ▶ **Excavation shoring and bracing and water removal also key activities**
- ▶ **Maintain adequate LTTD spare parts supply onsite**
- ▶

AMERICAN THERMOSTAT SITE

LESSONS LEARNED SUMMARY

(CONTINUED)

- ▶ **Ensure adequate, available make-up water source**
- ▶ **Use multiple treated residue bins**
- ▶ **Consider productivity impacts of severe weather**
- ▶ **Designate appropriate PPE requirements**
- ▶ **Specify key LTTD staffing needs carefully**
- ▶ **Request pricing breakout for optional items or for quantity underrun / overrun situations**

SUMMARY

LOW TEMPERATURE THERMAL DESORPTION

MOST COMMON TECHNOLOGY

ROTARY DRYER SYSTEM

- ▶ **Versatile and proven technology**
- ▶
- ▶ **Able to accept solids, liquids, and sediments**
- ▶
- ▶ **Adaptable to changeable site conditions**
- ▶
- ▶ **Generally reliable**
- ▶
- ▶ **High rate, continuous feed throughput, beyond 100 tons/hr.**
- ▶
- ▶ **Most prevalent, hence more competition from various vendors**
- ▶
- ▶ **Some vendors have existing units that can alternately be used in high temperature thermal desorption or incineration applications**
- ▶
- ▶ **Regulatory track record more established than other technologies**
- ▶

LTTD VIDEO

Available from NFESC